FM Triage: A Credible and Affordable Process for Better Repair/Replace Funding Decisions

James B. Clayton, PE[1],
Albert Antelman, RA[2],
James J. Dempsey PE, CDR USCG[3]

Abstract

Facility managers need credible and affordable decision support processes to help them allocate limited repair and replacement dollars with maximum utility. This paper describes one such process, *Facilities Management Triage,* which applies the concept of *battle and catastrophe medical triage* to the ASTM Standard practice for Prioritizing Asset Resources in Acquisition, Utilization, and Disposition.

FM-Triage also harnesses the powerful principals of operational risk management to optimize the long-term utility of repair/replace decisions while minimizing the costs of data collection. The result is a credible and relatively low-cost process for forecasting and ranking repair and replacement projects to best achieve the organization's desired mission outcomes and facility stewardship goals. The risk-based process can be used as the basis for justifying budgets, allocating funds, selecting projects for execution, assessing performance, and screening-out candidate projects that can be deferred with no impact on mission outcomes.

This paper presents a case study of how one facility manager used *FM-Triage* for making better decisions, illustrating the significant benefits and cost savings potential compared to traditional methods.

Introduction

Triage is a French word meaning sorting. It commonly describes a process used in battlefield and catastrophe environments by medical personnel to ration limited medical resources when the number of injured needing care exceeds the resources available so as to treat the greatest number of patients possible. As a result of *medical triage*, some injuries receive immediate care, some injuries are treated later, and some injuries receive minimal care because the injured person is unlikely to survive.

Some ideas from *medical triage* can be adapted to help facility managers apportion limited financial resources to yield optimum utility when the number of building components needing repair or replacement exceeds available resources. *Facilities Management Triage (FM-Triage)* identifies and ranks projects that should be funded immediately, projects that must be deferred until more funds arrive, and projects that should receive no funding.

Foundation of FM Triage - Disciplined, Quantitative Decision-making

ASTM Standard E 2495-07[4] gives facility managers a disciplined, quantitative approach to an inherently subjective decision-making process: determining relative importance of alternatives based on criteria that are important to the organization. This method is widely used and provides a rational, defensible approach for prioritizing alternatives. The standard is based on natural human thought process and has a wide range of application in facility management including the ranking of repair and replacement projects. It cannot replace education or experience, but when used with professional judgment, it forms a credible basis for sound business decisions. Such credibility is helpful in winning upper management support for funding requests and project selection. Another advantage of using the ASTM Standard is that it employs a mathematical model that lends itself to group decision-making, as

[1] James B Clayton, PE, Principal, CALIBRE Systems, Inc., Alexandria, VA 22015. jim.clayton@calibresys.com
[2] Albert Antelman, Naval Facility Engineering Service Center, Port Hueneme, CA 93043. albert.antelman@navy.mil
[3] James J. Dempsey PE, CDR USCG Executive Officer, CEU Oakland, Oakland, CA 94606-5337. james.j.dempsey@uscg.mil
[4] ASTM E 2495-07: Standard Practice for Prioritizing Asset Resources in Acquisition, Utilization, and Disposition. This practice is under the jurisdiction of ASTM Committee E53 on Property Management Systems and is the direct responsibility of Subcommittee E53.05 on Property Management Maturity. Current edition approved Feb. 1, 2007. Published March 2007. Originally approved in 2006. Last previous edition approved in 2006 as E 2495 – 06.

well as simple analysis by spreadsheet. These attributes aid consensus-building among organizational elements competing for limited repair and replacement dollars and also promote the understanding and credibility of budget requests and fund allocation plans.

Enhancing ASTM Standard Practice E 2495-07 with Ideas from Medical Triage

Organizations that prioritize facility repair and replacement projects can benefit by using ASTM Standard Practice E 2495-07. They can obtain considerable additional benefit by incorporating a few ideas from medical triage into the Standard Practice. The combination is called FM Triage and the following case study illustrates how one facility manager produced excellent results by using the hybrid method. The case study is based on actual events and people.

Jeff Wright is the senior facility manager for an organization that owns and operates an 18M GSF portfolio of 450 buildings located in 12 divisions across a tri-state area. Every year, he assembles for a full day the divisional facility managers in order to reach consensus on which of many capital repair and replacement project candidates will actually be executed with available funds.

The end-product of his meeting is a list of proposed projects, such as Figure 1, ordered top to bottom from highest to lowest rank. The prioritized list displays estimated cost of each project as well as the cumulative costs of adding each project to the list. By comparing cumulative costs with available funds, Jeff's group draws a cutoff line that determines which projects will be funded and which will not. The final list is submitted to upper management for approval before Jeff orders project execution.

2007 Repair/Replacement Project Priority List

Project Number	Division	Facility Name	Project Description	Rank	Estimated Cost	CUM Cost
2004-1	A	Cafeteria/Galley	Repair Loading Dock	1	$ 150,000	$ 150,000
2004-3	B	Information Technology	Repair HVAC System	2	$ 165,000	$ 315,000
2004-6	E	Library	Install New 400 Amp Panel & Wiring	3	$ 180,000	$ 495,000
2004-2	A	Headquarters	Interior Painting and Carpeting	4	$ 100,000	$ 595,000
2004-7	F	Clinic	Replace Existing Doors & Windows	5	$ 260,000	$ 855,000
2004-5	D	Warehouse	Repair Roof	6	$ 152,000	$ 1,007,000
2004-4	C	Conference Center	Install New Interior Lighting Fixtures	7	$ 145,000	$ 1,152,000
2004-8	G	Garage	Replace Hydraulic Hoist	8	$ 125,000	$ 1,277,000

Funded For $900K Budget

Not Funded

Table 1

Two years ago, after Jeff had been promoted from divisional facility manager, he decided to streamline the annual prioritization process and make its end product more credible to upper management. As a divisional facility manager, he had been disappointed with previous meetings, where most of the time was spent watching PowerPoint presentations of proposed projects and trying to participate in subjective, free-for-all discussions dominated by strong personalities vying for their own fair share of the repair and replacement budget. He also knew that upper management was not impressed with the funding choices made by the group and had repeatedly countermanded the recommended lists.

So, Jeff decided to conduct the 2006 annual meeting along the lines of a popular decision-making process he had read about called the analytical hierarchy process (AHP)[5]. This proved a good choice because ASTM International had just adopted AHP as the basis for its "Standard Practice for Prioritizing Asset Resources in Acquisition, Utilization, and Disposition." The ASTM endorsement further enhanced the credibility of Jeff's streamlined process in the eyes of upper management.

[5] Satty, T.L., *Fundamentals of Decision Making and Priority Theory,* RWS Publications, 4922 Ellsworth Ave., Pittsburgh, PA 15213, 1994.

Jeff knew that AHP was being used successfully in government and industry to rank/prioritize sets of alternatives in strategic planning, resource allocation, source selection, business/public policy, program selection, and much more. But he could find no references using AHP for ranking facility projects. Undaunted, he planned his first meeting to follow the prescribed steps of AHP:

1. Clarify the Objective
2. Choose Selection Criteria
3. Weight the Selection Criteria
4. Create a Scoring Scale and Score Alternatives against each Weighted Selection Criterion
5. Calculate Benefit/Cost Ratio of each Alternative
6. Rank Alternatives according to Benefit/Cost Ratios

The results of the 2006 meeting were encouraging. Most group members shared Jeff's desire for improvement and readily agreed to try the AHP process. The group breezed through Step #1 (Clarify the Objective), but spent most of the morning making slow progress on Step #2: (Choosing Selection Criteria).

Step #2 of the AHP process (and now ASTM Standard Practice # 2459-07) requires managers to develop a set of prioritizing criteria that meets rigid specifications. One specification is that the criteria set must be "collectively exhaustive." While trying to be "collectively exhaustive," the group compiled a long list of possible criteria. The list included many diverse candidates such as mission support, current physical condition, ROI, customer preference, top management emphasis, remaining service life, remaining maintenance life, system importance, current facility use, and future facility use. After several hours of discussion, a group member pointed out that the longer the list of criteria, the more tedious and time-consuming would be the following steps of the AHP process. This enmeshed the group in a push-pull argument between the need to be "collectively exhaustive" and the need to complete the process in the allotted time[6].

A breakthrough came when one of Jeff's staff members, an Army Reserve medic, suggested that the group apply an idea he had learned in triage training: <u>simplify screening by using the fewest criteria possible.</u> Some group members recognized his idea as the old "80/20" rule, but everyone agreed that "collectively exhaustive" did not necessarily mean a long list of criteria. A productive discussion resulted in consensus that, for repair/replacement projects, just three selection criteria could produce credible results with the AHP process: (1) Mission Alignment, (2) Condition Improvement, and (3) Financial Performance. The group further defined these criteria as follows:

Criteria #1: <u>Mission Alignment</u> - as determined by:

- **System Importance -** relative importance of the system(s) that would be repaired/replaced by the proposed project compared to all other systems in the parent facility[7].
- **Facility Importance -** relative importance of the parent facility in supporting one or more predominant mission elements compared to the importance of all other facilities in supporting their respective predominant mission elements.

---

[6] Unknown to the group, use of more than three selection criteria in the AHP process also requires the purchase and deployment of specialized, heuristic software in place of a standard computer spreadsheet.

[7] In organizations that own facilities having common characteristics (e.g. a logistics company owning just warehouses), this sub-criterion drops out of the analysis because each system in each facility of the portfolio has the same relative importance to the functioning of its parent facility, thereby negating any reason to favor one alternative over another on the basis of relative system importance.

- **Mission Element Importance -** relative importance of a facility's predominant parent mission element compared to all other mission elements of the organization.

Criteria #2: <u>Condition Improvement</u>

- as determined by the anticipated change to physical condition of the system(s) that would be repaired/replaced by the proposed project

Criteria #3: <u>Financial Performance</u>

- as determined by the benefit/cost ratio of the proposed project

With half the day gone and four more steps yet to go, Jeff decided to temporarily set aside AHP and revert to the customary free-for-all discussions in order to produce the 2006 priority list by day's end. Nonetheless, the group decided to discuss and select candidate projects only in terms of the new selection criteria. Afterwards, all agreed that this limitation produced a useful focus that never before had been experienced at an annual prioritization meeting. If improvement could be made by implementing just two AHP steps, think of the potential of implementing all six steps. Many group members also spoke positively about other possible applications of the AHP process: prioritization of non-capital maintenance and repair jobs; capital and non-capital alteration and improvement projects; selection of buildings to be inspected with limited inspection funds; even space and room assignments.

Heartened by meeting outcomes, Jeff enlisted several willing divisional facility managers and two members of his own staff to work with him on a "Tiger Team" that would further adapt and fine tune the AHP process to their organization's particular needs. At the first of such meetings, team members realized that, having already identified a good set of selection criteria, the biggest remaining challenge would be Step #4. All other steps were clear-cut mathematical operations that could be easily pre-programmed on a computer spreadsheet using available data and group feedback during the next prioritization meeting.

Step #4 was seen as a formidable challenge because it required:

- For each selection criterion, management designs a scoring scale by which Subject Matter Experts (SMEs) can evaluate each alternative project
- SMEs use prescribed scales to score each alternative project in terms of each selection criterion
- management performs mathematical calculations to arrive at a composite "benefit" rating for each alternative

The prescribed mathematical calculations in Step #4 appeared to be clear-cut operations that could be easily pre-programmed on a computer spreadsheet, but the Tiger Team had great difficulty coming to grips with designing a scoring scale and a method for scoring the projects during the next prioritization meeting. The tasks seemed very complicated and too time consuming to accomplish during an annual one-day meeting.

The problem became simpler when someone realized that Step #4 did not apply to Criteria #3 - Financial Performance because scoring each project for financial performance was the essence of Step #6 and also could be easily pre-programmed in a computer spreadsheet using available data. Team members also stipulated that each building system in the organization's portfolio has the same relative importance to the functioning of its parent facility as does its counterpart system in all other facilities. This proviso negated any reason to favor one alternative above another on the basis of relative system importance, and further simplified the problem by eliminating the need to score alternative projects against the "System Importance" sub-criteria.

However, the Team kept pondering over how to design scoring scales and use them to obtain SME scores for the remaining criteria: <u>Mission Element Importance, Facility Importance, and</u>

Condition Improvement. Team members were also concerned about the cost of gathering and maintaining current the data needed to perform Step #4.

Another insightful comment from the Army Reserve medic led to another breakthrough. His triage idea was that, for consistency and time-efficiency, SMEs who perform medical triage use pre-established pro formas developed by other SMEs to screen candidates for treatment. This idea suggested to some Team members that, instead of performing Step #4 during the annual meeting, it should be done by others prior to the meeting and the results employed by meeting attendees to perform AHP tasks. This thought prompted Jeff's Tiger Team to research existing methods for scoring project candidates against the three remaining criteria. The research revealed three relevant and credible processes, including scaled indexes, which can be implemented at relatively low cost. Furthermore, all three processes and indexes are grounded in the principals of Operational Risk Management (ORM); a feature that Jeff believed would further enhance the credibility of future priority lists.

Harnessing the Power of Operational Risk Management - Another Foundation of FM Triage

Operational Risk Management (ORM)[8] was developed by the US Navy as a means to integrate risk analysis into operational decisions. At first, ORM focused on the safety of personnel and equipment, but its applicability to facilities soon became evident. The principle steps of ORM include identifying potential hazards, determining the associated degree of risk, and making a decision based on risk assessment.

FM Triage applies the ORM process by identifying the risks associated with observed distresses of facility components such as roofing, plumbing, and HVAC equipment. Once these risks are identified and classified according to type, severity and density, their hazard (failure) potential is calculated and those risks deemed unacceptable by pre-set management standards are converted into potential repair/replacement projects. The risk of deferring those projects and chancing the anticipated component failure is then assessed against the risk of mission degradation and presented to appropriate decision-makers who can review and determine overall risk acceptability and prioritize projects accordingly.

Using FM Triage, an organization can strengthen the credibility of its repair and replacement backlog by basing project deferral decisions on objective and repeatable analyses and broad views of the entire organization rather than on the subjective opinions and limited perspectives of tradesmen and engineers. Likewise, the organization can improve the quality of resource allocation decisions by structuring those decisions to minimize risk to the mission rather than to just backlog reduction. Most importantly, organizations that use FM Triage can anticipate breakdowns, reduce mishaps, lower costs, and provide for more efficient use of resources.

FM Triage will directly enhance communication between organizations and managers regarding facility condition and impact of funding decisions. Enhanced communications will result in better resource allocation decisions, and better decisions, in turn, will improve the physical condition of the organization's real property assets.

The Metrics of FM Triage

Jeff's Tiger Team decided to use the three newly-discovered metrics as the basis for conducting Step #4 at the 2007 annual meeting. The metrics are called Relative Mission Importance (RMI) Index, Mission Dependency Index (MDI) and Building Condition Index (BCI) Series.

Relative Mission Importance (RMI) Index

Originated by the US Coast Guard (USCG) Office of Civil Engineering, the Relative Mission Importance Index is a number between 0 and 100 that represents the relative importance of a facility's purpose in relation to an organization's mission elements. RMI is based on the

[8] OPNAVINST 3500.39B, Operational Risk Management (ORM)

collective judgments of executive level decision-makers who have a strategic role in the resource allocation decision process. Each decision-maker participates in a short, structured annual interview designed to elicit data, which are subsequently used to determine relative importance scores by way of one mathematical technique used in the Analytic Hierarchy Process (AHP) called "pair-wise comparison." Scores are normalized on a scale of 0 to 100, with 100 representing the highest importance.

Mission Dependency Index (MDI)[9]

The Naval Facilities Engineering Command (NAVFAC), the United States Coast Guard (USCG), Office of Civil Engineering and the National Aeronautical and Space Administration (NASA) have partnered in deployment of a risk-based metric that links facilities to specific mission elements. This metric is called Mission Dependency Index or MDI.

The MDI supports and is consistent with all Federal Facility Asset Management principles and has been recognized and endorsed by the General Services Administration[10], the National Academy of Sciences' National Research Council, the Federal Facilities Council[11] and the Association of Higher Education Facility Officers (APPA)[12].

MDI uses Operational Risk Management (ORM) techniques of probability and severity and applies them to facilities in terms of interruptability, relocatability and replaceability. The process of determining MDI also considers other factors such as, environmental hazards, high cost equipment, high personnel occupancy, unique facilities, emergency facilities, quality of life, safety, and historic preservation.

MDI also takes into account mission intra-dependencies (those that reside within an organizational component) and mission inter-dependencies (those that reside between organizational components). It does this through a structured interview process that captures the experience, judgment, intuition and situational awareness of local leaders having authority over local operational and facility decisions. The product of the interviews is a quantitative score normalized over a scale from zero to one hundred, with higher scores representing higher mission dependencies and mission critical facilities.

MDI's true power is its simplicity and ease of use. It is risk-based and, due to the structured interview process, is consistent, repeatable, auditable and less subjective. MDI scores simply communicate a critical and heretofore missing detail in infrastructure-related decision-making: linking facilities to mission elements.

Building Condition Index (BCI) Series

The U.S. Army Engineering Research and Development Center (ERDC-CERL) developed BCI series as a key element of the BUILDER® process for facility assessment and capital planning[13]. The next-generation process is already being employed by two Federal agencies and others who want to reduce inspection and repair costs; improve credibility of condition assessments and repair budgets; enable better funding allocation and project selection; and allow meaningful tracking of spending impact.

---

9 Antelman A., and Miller, C. (2002). Special Publication SP-2113-SHR, Mission Dependency Index Validation Report, Naval Facilities Engineering Command, Naval Facilities Engineering Service Center, Port Hueneme, CA.

10 http://www.fmlink.com/ProfResources/BestPractices/

11 http://darwin.nap.edu/books/0309089190/html/89.html

12 www.appa.org/files/pressreleases/070906_execsummary_buildingsais.pdf

13 BUILDER® is a set of patented business processes that could be performed manually, but there is a software element pulling it all together. The newest version of BUILDER® software is Web based and includes patented capability to support both condition and functional assessments and integrate all data into performance and risk-based strategic asset management

BCI emerged from the same research that produced the current ASTM standard for determining pavement condition (PCI)[14] and the BUILDER® process was rated "preferable choice" among 18 alternatives by a peer-reviewed ASCE paper[15]." The process delivers, at a fraction of the cost of traditional methods, data that Federal agencies need to meet specific requirements of the Federal Real Property Council's Guidance for Improved Asset Management.

BCI is a condition measure on a 0-100 scale (100 = distress free). A BUILDER® Life-Cycle Model computes a condition index for each *building component section*[16] and keeps each index constantly updated in real time with automatic science-based deterioration projections supplemented with fresh survey data. Survey data come from selectively-scheduled, standardized visual surveys that objectively collect risk-based data (distress types, severities, and densities) of *building component sections*. The Model also automatically re-calibrates the accuracy of its own projections based on latest survey data and rolls up component section condition indexes into condition indexes for parent systems, facilities, and portfolios.

This methodology is fundamental different and vastly superior to the traditional facility condition index (FCI), which is simply calculated as repair/replacement cost of a component, building or portfolio divided by the present replacement value of the component, building or portfolio. The Achilles heal to the FCI is in the definitions used for the numerator and denominator. Where BCI uses very explicit, auditable definitions, FCI definitions are known to vary widely or are inconsistently used across the industry or even at individual locations. This introduces great uncertainty when using FCI in support of funding allocation and prioritization. Many organizations also cannot afford the comprehensive inspections needed to support FCI calculations.

The 2007 Annual Prioritization Meeting

Encouraged by the new information, Jeff's Tiger Team planned the 2007 meeting to closely follow the AHP process. Only this time, they were resolved to complete all six steps in only a few hours, leaving plenty of time for the group to apply its engineering judgment to the results. On meeting day, Jeff sensed that the entire group was still receptive to change and willing to build on last year's positive experience with AHP. He began the morning session by reviewing the AHP process, and presenting the following list of candidate projects:

---

[14] ASTM D6433-03 Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys and ASTM D5340-04e1 Standard Test Method for Airport Pavement Condition Index Surveys

[15] Ottoman, Nixon, Lofgren, ASCE, "Journal of Management in Engineering," July/August 1999

[16] Building component-sections are the "management units" upon which work decisions are made. Examples: a group of four 50 lb/hr central humidifiers, same model and age. A component section's condition establishes work item scope and cost for that section.

2007 Repair/Replacement Candidate Projects

Project Number	Division	Facility Name	Project Description	Estimated Cost
2006-1	A	Cafeteria/Galley	Repair Loading Dock	$ 150,000
2006-2	B	Information Technology	Repair HVAC System	$ 165,000
2006-3	E	Library	Install New 400 Amp Panel & Wiring	$ 180,000
2006-4	A	Headquarters	Interior Painting and Carpeting	$ 100,000
2006-5	F	Clinic	Replace Existing Doors & Windows	$ 260,000
2006-6	D	Warehouse	Repair Roof	$ 152,000
2006-7	C	Conference Center	Install New Interior Lighting Fixtures	$ 145,000
2006-8	G	Garage	Replace Hydraulic Hoist	$ 125,000
				$ 1,277,000

Table 2

Under Jeff's leadership, the group again breezed through Step #1 (Clarify the Objective), and took just a few minutes to discuss and validate last year's choice of selection criteria to complete Step #2. Jeff also explained why "System Importance" had been dropped as a selection criterion and that the application of the "Financial Performance" criterion would be deferred until Step #6. Subsequent steps in the AHP process were quickly completed in turn, as follows:

Step #3 - Assign Weights to the Selection Criteria

Using a recommended scale and prescribed process called "pair-wise comparison," Jeff led the group in defining how important each selection criteria is in relationship to the others. The method required filling in a grid that has each criterion as both a row and column header as required by AHP. Jeff projected the computer spreadsheet on a screen so everyone could follow the action. Since the entire weighting process was pre-programmed in the spreadsheet, all the group had to do was reach consensus on the three numerical comparisons highlighted in blue in Figure 3 and enter the three numbers. The spread sheet did the rest.

Calculation of Criteria Weights

	Mission Element Importance	Facility Importance	Condition Improvement	Geometric Mean	Normalized Weights
Mission Element Importance	1.00	3.00	2.00	1.817	53%
Facility Importance	0.33	1.00	4.00	1.101	32%
Condition Improvement	0.50	0.25	1.00	0.500	15%
				3.418	100%

Table 3

In the grid, each criterion compared against itself (on the diagonal) is given a number "1," meaning "of equal importance." The three highlighted entries denote that group members rated Mission Element Importance a "3" compared to Facility Importance, and a "2" compared to Condition Improvement; and that Facility Importance was rated a "4" compared to Condition Improvement. To maintain consistency, the reverse comparisons (Facility Importance vs. Mission Element Importance, Condition Improvement vs. Mission Element Importance, and Condition Improvement vs. Facility Importance) are the reciprocal of measurement units on the scale of relative importance. Once the highlighted cells were populated, the spreadsheet automatically calculated reciprocals, Geometric Means, and Normalized Weights of the three selection criteria.

Step #4 - Create a Scoring Scale and Score Alternatives against each Weighted Selection Criterion

The computer spreadsheet automatically entered the normalized weights of the selection criteria into the appropriate cells of another spreadsheet depicted in Table 4 that Jeff also projected on a screen. The calculated 53% weight for “Mission Element Importance” from Table 3 automatically appeared in ever project cell in the “RMI-Wgt” column of Table 4; the 32% weight for “Facility Importance” appeared in ever project cell in the “MDI-Wgt” column; and the 15% weight for “Condition Improvement” appeared in ever project cell in the “Condition Improvement -Wgt” column.

Scoring Alternative Projects against Weighted Criteria

PROJ #	DIV	MISSION ALIGNMENT					Project Description	Condition Improvement			API	Rank by API
		Name	RMI		MDI							
			Index	Wgt	Index	Wgt		BCI	95-BCI	Wgt		
2006-1	A	Cafeteria/Galley	90	0.53	70	0.32	Repair Loading Dock	50	45	0.15	116	1
2006-6	D	Warehouse	70	0.53	70	0.32	Repair Roof	40	55	0.15	115	2
2006-2	B	Information Technology	80	0.53	100	0.32	Repair HVAC System	70	25	0.15	100	3
2006-8	G	Garage	45	0.53	20	0.32	Replace Hydraulic Hoist	30	65	0.15	96	4
2006-3	E	Library	50	0.53	100	0.32	Install New 400 Amp Panel & Wiring	60	35	0.15	94	5
2006-5	F	Clinic	90	0.53	60	0.32	Replace Existing Doors & Windows	70	25	0.15	92	6
2006-4	A	Headquarters	70	0.53	80	0.32	Interior Painting and Carpeting	70	25	0.15	88	7
2006-7	C	Conference Center	50	0.53	85	0.32	Install New Interior Lighting Fixtures	70	25	0.15	79	8

Table 4

Jeff explained the source of the criteria weights and pointed out that each project had already been scored against each criterion, as witnessed by the entries in the Index columns under Mission Alignment and Condition Improvement. He then explained the source of the scores:

How Projects were Pre-Scored for Mission Alignment

In the months prior to the meeting, Team members conducted two sets of interviews: one set to determine the importance of each of the organization’s mission elements relative to the organization’s eight mission elements, and one set of interviews to determine importance of each facility in the organization’s portfolio relative to the most relevant element of the organization’s mission. Pro forma procedures had been adapted from USCG documentation and Mission Element Importance interviews were conducted with each of the organization’s top five executives, including the CFO, the Executive VPs, and the President. Team members also followed pro forma procedures to calculate an RMI index for each mission element as well as assign an RMI index to each facility in the portfolio.

Team members also designed and conducted Facility Importance interviews and MDI calculations using pro formas that had been adapted from US Navy documents. These interviews involved at least one line manager from each facility in the portfolio as well as the operations manager of each of the 12 divisions and yielded an MDI for each facility.

Team members entered RMI and MDI scores into Table 4 several days before the meeting.

How Projects were Pre-Scored for Condition Improvement

After Jeff’s promotion to senior facility manager, he had been exploring ways to cut facility assessment costs without damaging the credibility of inspection data. His predecessor had reduced annual inspection costs considerably by inspecting just 1/3 of the portfolio every year in lieu of the recommended, annual comprehensive inspection. Consequently, inspection costs were down, but 2/3 of the organization's inspection data was always 2-3 years out of data and practically useless for management purposes.

Before forming his Tiger Team, Jeff had initiated a pilot project to test the ability of the BUILDER® process to reduce inspection costs while producing credible and constantly updated assessment data for entire portfolios. The pilot proved successful and, when the Tiger Team expressed an interest in using BUILDER's BCI as one of its selection criteria, Jeff ordered full BUILDER implementation for all 450 facilities. The initial assessment cost him less than the budgeted amount to continue one-in-three traditional inspections, cut second year inspection costs by 60%, and produced the BCI data for each building component that the Tiger Team needed to improve the repair/replacement project prioritization process.

Jeff then explained to the 2007 meeting participants that the Asset Priority Index (API) was the end result of Step #4 and that the electronic spreadsheet automatically calculated it according to the following equation:

$$\mathbf{API|_{\text{project x}} = (RMI \times Weight|_{RMI}) + (MDI \times Weight|_{MDI}) + [(95 \text{ minus } BCI) \times Weight|_{BCI}]}$$

Note that the metric used for "Condition Improvement" was "95 minus BCI" rather than just "BCI." This is because the Tiger Team recognized that "Condition Improvement" is actually the numerical difference of a component's condition index after the repair/replacement and the component's condition index before the repair/replacement. The Team had also assumed that a BCI of 95 was a more reasonable expectation for any completed repair/replacement project than a "like new" BCI of 100.

With APIs calculated, Jeff created Table 4 by re-sorting the table rows according to API and filling in the column labeled "Rank by API."

Step #5 - Calculate Benefit/Cost Ratio of each Alternative

After explaining how projects had been scored against the weighted selection criteria and the scores used to calculate API, Jeff showed the group Table 5, which is part of the same spread sheet shown in Table 4 with some columns hidden and several new ones visible.

Calculated Benefit/Cost Ratio and Ranking

Proj #	DIV	Name	Project Description	API	Rank by API	Estimated Cost	Normalized Cost	Benefit-to-Cost Ratio	CUM Cost	Ranking by B/C Ratio
1	A	Cafeteria/Galley	Repair Loading Dock	116	1	$ 150,000	0.114	1,011	$ 150,000	1
6	G	Garage	Replace Hydraulic Hoist	96	4	$ 125,000	0.095	1,002	$ 275,000	2
4	D	Warehouse	Repair Roof	115	2	$ 152,000	0.116	992	$ 427,000	3
5	A	Headquarters	Interior Painting and Carpeting	88	7	$ 135,000	0.103	856	$ 562,000	4
3	B	Information Technology	Repair HVAC System	100	3	$ 165,000	0.126	794	$ 727,000	5
7	C	Conference Center	Install New Interior Lighting Fixtures	79	8	$ 145,000	0.111	716	$ 872,000	6
8	E	Library	Install New 400 Amp Panel & Wiring	94	5	$ 180,000	0.137	685	$ 1,052,000	7
2	F	Clinic	Replace Existing Doors & Windows	92	6	$ 260,000	0.198	466	$ 1,312,000	8
						$ 1,312,000				

Table 5

The spreadsheet had been pre-programmed to calculate the Benefit/Cost Ratio of each candidate project. Estimated budget cost of each project had been produced by the BUILDER process when the process first identified the projects. Costs were entered in the spreadsheet before the meeting and the spreadsheet had immediately calculated a "normalized cost" for each project by dividing a project's estimated cost by the sum of all project costs. Then, as soon as API's were calculated during the meeting, the spreadsheet automatically calculated Benefit/Cost Ratios for each project by dividing the projects API by its normalized cost.

Step #6 - Rank Alternatives According to Benefit/Cost Ratios

Upon displaying Table 5 on the projected spreadsheet, Jeff simply used the spreadsheet sorting function to rank the alternative projects according Benefit/Cost Ratios.

Post Process Discussions

With the thorough advance planning and preparation done by Jeff's Tiger Team, it took the group only three hours to complete all six steps of the AHP process. This left plenty of time for the group to digest results and decide what the final list should look like. Most group members were hesitant to accept any machine results without further discussion. They liked the AHP process, the time-saving aspects of employing a standard spreadsheet to run the process, and the indexes used to score each alternative. Most were impressed with the operational risk management methods used to obtain the index values - especially the process that produced a credible condition index and other useful data while cutting inspection costs.

A concern was voiced about the obvious ability to game the results by manipulating the weights assigned to selection criteria in order to control API scores and Benefit/Cost Ratios. All agreed that more thought needed to be devoted to eliminating that particular vulnerability in the future, but concluded it would not affect the credibility of this year's list.

More discussions determined that the group's main hesitancy in accepting the machine ranking was because the process had actually yielded two different sets of rankings, one based on API scores and the other based on Benefit/Cost Ratios. Which was the "right" set? To help clarify the issue, Jeff used the spreadsheet's graphing capability to create Figure 1, which he projected on the screen. Each dot represents a candidate project, labeled according to its assigned project number 1-8. Each project dot is plotted on the grid at a location corresponding to its calculated API and Benefit /Cost Ratio. For instance, Project #1 is located at Benefit/Cost Ratio1011 and AP value 116.

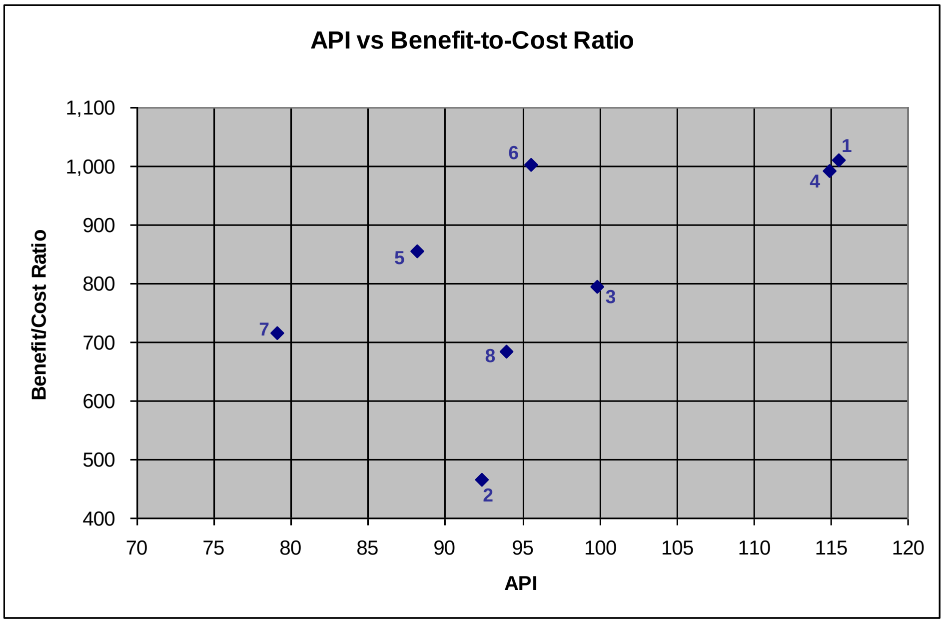

Figure 1

Jeff's graph helped everyone remember that candidate projects having the highest Benefit/Cost Ratio do not necessarily produce the most benefit for the organization and that, sometimes, the anticipated benefit is more important than getting the most bang for the buck. AHP and machine scoring can help sort out the picture, but human experience and judgment will always be required to determine best choices under various circumstances. The process cannot replace education or experience, but when used in conjunction with professional judgment, it forms a credible basis of good business decision.

Conclusions

FM-Triage help provide credible and affordable solutions to a complex problem by ranking repair and replacement projects to produce supportable funding decisions designed to achieve optimum utility with limited financial resources. The process also can be used to screen-out projects that should be deferred if they have little or no relevance to an organization’s mission.

The use of 3-4 pre-determined prioritization criteria reduces the time and frustration that could be encountered when using ASTM Standard Practice E 2495-07 to prioritize repair/replacement projects without sacrificing credibility of results and consensus.

Three credible, scaled indexes for scoring alternatives already exist and can be implemented at relatively low cost. Using these credible indexes greatly reduces cost of collecting condition data and time required to reach consensus on the prioritization of repair/replacement projects.

Acknowledgements and Disclaimer

Relative Mission Importance Indexing is the creation of United States Coast Guard, Office of Civil Engineering.

Mission Dependency Indexing was conceived and developed by the Naval Facilities Engineering Services Center in partnership with United States Coast Guard, Office of Civil Engineering. Additional funding and sponsorship was provided by Office of Naval Research (ONR), Naval Facilities Engineering Command (NAVFAC), Commander Naval Installations (CNI), and the National Aeronautical and Space Administration (NASA).

The Building Condition Index concept was developed at ERDC-CERL and the former Army Center for Public Works.

CALIBRE Systems, Inc. holds a Commercial Evaluation License from ERDC-CERL and assisted in refining the BCI inspection process.

The authors gratefully acknowledge the long-term efforts of Dr. Don Uzarski (formerly with ERDC CERL) and Messrs. Lance Marrano and Mike Grussing at ERDC-CERL.

The views of the authors do not purport to represent the views or policies of any Federal agency.